Use of Pediatric Open, Laparoscopic and Robot-Assisted Laparoscopic Ureteral Reimplantation in the United States: 2000 to 2012

Diana K. Bowen, Mark A. Faasse, Dennis B. Liu, Edward M. Gong, Bruce W. Lindgren and Emilie K. Johnson*

Division of Pediatric Urology, Ann and Robert H. Lurie Children's Hospital of Chicago, Feinberg School of Medicine, Northwestern University, Chicago, Illinois

Purpose: We characterize the use of pediatric open, laparoscopic and robot-assisted laparoscopic ureteral reimplantation in the United States from 2000 to 2012.

Materials and Methods: We used the Kids' Inpatient Database to identify patients who underwent ureteral reimplantation for primary vesicoureteral reflux. Before 2009 laparoscopic ureteral reimplantion and robot-assisted laparoscopic ureteral reimplantation were referred to together as minimally invasive ureteral reimplantation. A detailed analysis of open vs robot-assisted laparoscopic ureteral reimplantation was performed for 2009 and 2012.

Results: A total of 14,581 ureteral reimplantations were performed. The number of ureteral reimplantations yearly decreased by 14.3%. However, the proportion of minimally invasive ureteral reimplantations increased from 0.3% to 6.3%. A total of 125 robot-assisted laparoscopic ureteral reimplantations were performed in 2012 (81.2% of minimally invasive ureteral reimplantations), representing 5.1% of all ureteral reimplantations, compared to 3.8% in 2009. In 2009 and 2012 mean ± SD patient age was 5.7 ± 3.6 years for robot-assisted laparoscopic ureteral reimplantation and 4.3 ± 3.3 years for open reimplantation ($p < 0.0001$). Mean ± SD length of hospitalization was 1.6 ± 1.3 days for robot-assisted laparoscopic ureteral reimplantation and 2.4 ± 2.6 for open reimplantation ($p < 0.0001$). Median charges were $22,703 for open and $32,409 for robot-assisted laparoscopic ureteral reimplantation ($p < 0.0001$). These relationships maintained significance on multivariate analyses. On multivariate analysis robot-assisted laparoscopic ureteral reimplantation use was associated with public insurance status ($p = 0.04$) and geographic region outside of the southern United States ($p = 0.02$). Only 50 of 456 hospitals used both approaches (open and robotic), and only 6 hospitals reported 5 or more robot-assisted laparoscopic ureteral reimplantations during 2012.

Conclusions: Treatment of primary vesicoureteral reflux with ureteral reimplantation is decreasing. Robot-assisted laparoscopic ureteral reimplantation is becoming more prevalent but remains relatively uncommon. Length of stay is shorter for the robotic approach but the costs are higher. Nationally robot-assisted laparoscopic ureteral reimplantation appears to still be in the early phase of adoption and is clustered at a small number of hospitals.

Key Words: pediatrics, replantation, robotics, urologic surgical procedures, vesico-ureteral reflux

Abbreviations and Acronyms

KID = Kids' Inpatient Database

LOS = length of stay

LUR = laparoscopic ureteral reimplantion

MIR = minimally invasive ureteral reimplantation

OR = open ureteral reimplantation

PHIS = Pediatric Health Information System

RALUR = robot-assisted laparoscopic ureteral reimplantation

UR = ureteral reimplantation

VUR = vesicoureteral reflux

Accepted for publication February 2, 2016.

No direct or indirect commercial incentive associated with publishing this article.

The corresponding author certifies that, when applicable, a statement(s) has been included in the manuscript documenting institutional review board, ethics committee or ethical review board study approval; principles of Helsinki Declaration were followed in lieu of formal ethics committee approval; institutional animal care and use committee approval; all human subjects provided written informed consent with guarantees of confidentiality; IRB approved protocol number; animal approved project number.

* Correspondence: 225 E. Chicago Ave., Box 24, Chicago, Illinois 60611 (telephone: 312-227-4000; FAX: 312-227-9412; e-mail: ekjohnson@luriechildrens.org).

0022-5347/16/1961-0207/0
THE JOURNAL OF UROLOGY®

http://dx.doi.org/10.1016/j.juro.2016.02.065
Vol. 196, 207-212, July 2016
Printed in U.S.A.

Ureteral reimplantation is one of the primary surgical treatments for vesicoureteral reflux in children. Laparoscopic ureteral reimplantation was introduced in the early 1990s and robot-assisted laparoscopic ureteral reimplantation followed roughly a decade later.[1] Initial results of the robot-assisted approach were encouraging, with a shorter learning curve than conventional laparoscopy, decreased postoperative pain and earlier return to normal activity compared to open surgery.[2–4]

A small number of studies have examined recent trends in use of antireflux surgery.[5,6] A 2010 analysis of the PHIS database found that the number of URs performed at pediatric hospitals in the United States was relatively stable from 2003 to 2007. However, the overall number of antireflux procedures increased, reflecting greater use of endoscopic bulking therapy.[6] This study did not compare specific approaches to UR, and the extent of diffusion of minimally invasive techniques (laparoscopic or robotic) was not addressed. Additionally the current American Urological Association guidelines on VUR do not mention laparoscopic or robotic modalities for surgical correction of VUR since there were too few reports to permit assessment when the guidelines were published in 2010.[7]

The available literature on the use and outcomes of OR, LUR and RALUR comes from small, single institution series.[4,8,9] To gain perspective, we used a population based approach to characterize the current use, temporal trends in usage and cost of UR modalities in the United States. We hypothesized that while UR may be performed less frequently through time, RALUR as a modality for correction of primary vesicoureteral reflux is becoming more common.

METHODS

Data Source

We conducted a retrospective cohort study using the Kids' Inpatient Database (https://www.hcup-us.ahrq.gov/kidoverview.jsp). KID is maintained as part of HCUP (Healthcare Cost and Utilization Project) and represents a stratified sample of discharge data for patients younger than 21 years drawn from all community and specialized nonrehabilitation hospitals in participating states. The database represents a national sample of 10% of all pediatric discharges in the United States, and KID provides survey weights for producing national estimates. KID is available every 3 years, beginning with 1997, and the number of states participating has increased from 22 in 1997 to 44 in 2009. For each year of available data this number represents 2 million to 3 million pediatric inpatient records from 2,500 to 4,100 hospitals.

KID contains information on all patients, regardless of payer, and hospitals are included through their statewide inpatient database if their state is a participating member in HCUP. Hospitals are grouped into "pediatric focused," which restrict admissions to children, and "nonpediatric focused," which admit adults and children. Hospitals are also designated as "teaching hospitals" based on an indicator provided by the Children's Hospital Association or inclusion in KID for the criteria 1) residency training approval by ACGME (Accreditation Council for Graduate Medical Education), 2) membership in the Council of Teaching Hospitals and Health Systems or 3) a ratio of full-time equivalent interns and residents to beds of 0.25 or greater.

Cohort Assembly

Patients who underwent OR, LUR or RALUR for primary vesicoureteral reflux were identified in the 2000, 2003, 2006, 2009 and 2012 KIDs by having an ICD-9 code for reflux (593.70) and ureteroneocystostomy (56.74) with or without laparoscopic approach (54.21). The robotic modifier code (17.42) was introduced in the 2009 data set and used in the 2009 and 2012 data sets, whereas the 2000 to 2006 data sets were stratified as open vs minimally invasive ureteral reimplantation. Exclusion criteria consisted of age 18 years or older and presence of a secondary cause of VUR, including kidney transplant (V42.0), posterior urethral valves (753.6), bladder exstrophy (753.5) and myelomeningocele and/or neurogenic bladder (741.0, 741.9, 344.6, 344.61).

Statistical Analysis

Descriptive statistics were used to characterize the population of patients undergoing UR for primary VUR who were represented in the data set. Characteristics of patients undergoing OR vs MIR were compared using univariate statistics.

The prevalence of each modality studied was estimated using KID specific weighting and sampling strategies. The Cochran-Armitage test was used to assess the trend of use of the treatment modalities each year. A detailed analysis of OR vs RALUR in 2009 and 2012 was performed. Chi-square test was used to compare proportions of OR vs LUR and RALUR between years. Generalized estimating equations were used to determine adjusted relationships between patient/hospital factors and reimplant modality (OR vs MIR) and use parameters such as length of hospital stay and charges. An exploratory analysis was conducted to delineate the distribution of procedures among hospitals performing OR and RALUR. A random effect for specific hospital was included in the regression model to account for clustering by hospital. All statistical tests were performed using SAS®, version 9.4, and statistical significance was determined at $p < 0.05$.

RESULTS

A total of 14,581 URs were recorded in the KID data sets from 2000 to 2012, representing a national estimate of 24,819 procedures. Of all URs 14,235 (97.6%) were OR and 346 (2.4%) were MIR. Overall the number of URs decreased from 2,870 in the 2000 data set to 2,480 in 2012 (14.3%). However, during this period the proportion of MIRs increased from 0.3% to 6.3% ($p < 0.00001$ for trend, fig. 1).